BASIC SOILS AND AIRFIELD CONSTRUCTION

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AVIATION GROUND SUPPORT

LESSON PURPOSE

- To familiarize the student with a basic understanding of soils and soil classifications
- To understand basic construction characteristics and design considerations of a flexible-pavement airfield
- Understand soil stabilization and methods available

ENABLING LEARNING OBJECTIVES

- Define soil and describe the Unified Soils Classification System (USCS) and three major categories of soils
- State the characteristics of the desired properties of soil groups
- Define a typical flexible-pavement structure and the layers that make up a flexible-pavement structure
- Describe the four methods of soil stabilization

BACKGROUND

- As Marines, should understand the effects of terrain and weather
  - MAGTF - Ability to maneuver effectively within the battle space
  - Aviation - Project power through expeditionary or forward basing assets
- As MWSS planner, should understand soils and airfield construction to better conduct BRAAT / RRR operations

SOILS

- Knowledge of soils essential for design and construction of roads and airfields
- If time and sources available, conduct a complete soil study
- Due to expeditionary nature, may need to do visual inspection and field analysis
- Decide if soil is suitable for:
  - Construction - compaction and drainage
  - Frost sensitivity
  - Soil stabilization/ scope of engineer work

SOILS

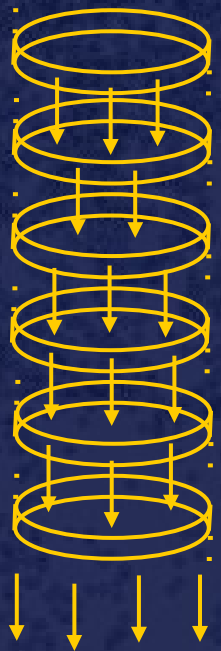
- Definition
  - The entire unconsolidated material that overlies bedrock and is clearly distinguishable from bedrock
    - Composed principally of disintegrated and decomposed products of rock
    - Contains air and water
    - Contains organic material derived from decomposition of plants and animals

SOILS

- Gradation
  - Soils may be divided into several different groups based on size of particles included in each group
  - Use of Unified Soils Classification Scale

SOILS

- Gradation (cont)
  - Several methods to determine the size of particles contained in a soil and distribution of particle sizes
  - Most common method is the Sieve Analysis
    - Soil separated by shaking through nest of sieves
    - Sizes are 3, 2, 1 1/2, 1, 3/4, and 1/4
    - Also US Standard No. 4, 10, 20, 40, 60, 100, 200
    - No. 4 has 4 groupings per lineal inch



SOILS

	US Standard Sieve size	
Type	Passing	Retention
Cobbles	No max size	3 in
Gravel	3 in	No. 4
Sand	No. 4	No. 200
Fines	No. 200	No min
Organic Matl	No size boundary	

SOILS

- Gradation (cont)
  - Gradation can be further broken down into its distribution

WELL-GRADED SOILS

UNIFORMLY-GRADED SOILS

GAP-GRADED SOILS

SOILS

- Gradation (cont)
  - Well-graded soils - A soil having a good representation of all particle sizes from largest to smallest
  - Uniformly-graded - Soil that consists predominately of uniform particle size
  - Gap-graded - Soils that contain some large and small particles but continuity is broken by absence of certain sizes

SOILS

- Effects of Gradation
  - Coarse materials that are well-graded usually preferable
    - Good gradation conducive to high density and stability
  - Proportioning components to obtain well- graded soil possible to provide for maximum density
    - Develops "interlocking" of particles
    - Makes soil stronger and capable of supporting heavier loads

SOILS

- Unified Soils Classification System(USCS)
  - Soils seldom exist separately as sand, gravel, or other single component
  - Usually mixtures of varying proportions of particles of different sizes
  - Each component contributes its own characteristics
  - USCS based on characteristics of the soils
  - Indicates how it will behave as a construction material

SOILS

- USCS (cont)
  - All soils divided into three major categories:
    - Coarse-grained soils
    - Fine-grained soils
    - Organic soils
  - Coarse-grained and fine-grained soils differentiated by grain size
  - Organic soils are identified by presence of large amounts of organic material, such as peat

SOILS

- USCS (cont)
  - Further divides soils based on major categories into letter symbols:
    - Gravel = G
    - Sand = S
    - Clay = C
    - Silts = M
    - Organic = O
  - Further break into further sub-categories
  - Appendix A and B

SOILS

- USCS (cont)
  - Coarse-grained soils are those in which at least half the material by weight is larger than a No. 200 sieve (retained on)
    - Two major divisions: Gravels and Sands
    - Determined by sieve analysis
    - Can be further broken down into sub- groups, as illustrated in Appendix A
  - Generally have good construction characteristics

SOILS

- USCS (cont)
  - Fine-grained soils are those in which more than half the material is smaller than a No. 200 sieve (passes)
  - Classified according to plasticity and compressibility, vice grain size distribution
    - L groups have liquid limits < 50 %
    - H groups have liquid limits ≥ 50 %
  - Generally “fair to unsuitable” for horizontal construction with low CBR values

SOILS

- Characteristics
  - Desired properties for foundations
    - Adequate strength
    - Good compaction characteristics
    - Adequate drainage
    - Resistance to frost action
    - Acceptable compression and expansion characteristics
  - General characteristics of soils groups presented in Appendix C

SOILS

- Appendix C
  - Columns 1 through 5 - Soils divisions, group symbols, hatching/color symbols
  - Column 6 - Name of soil types
  - Column 7 through 9 - Performance of soil as sub-grade, sub-base and base course
  - Column 10 - Potential frost action
  - Column 11 - Compressibility and expansion
  - Column 12 - Drainage characteristics
  - Column 13 - Compaction equipment
  - Column 15 - CBR

SOILS

- Appendix C Information and Overview
  - Coarse-grained soils best
  - Poor gradation reduces value and strength
  - Compensate by increasing base material thickness
  - Sand-clay-gravel best for unsurfaced roads
  - Properly designed drainage if required
  - Good compression (compaction) required for stability

SOILS

- California Bearing Ratio
  - Defined as a measure of shearing resistance of a soil under carefully controlled conditions of density and moisture
    - Determined by penetration shear test and uses empirical design curves
  - May range from 5 or less for CH type soils or may be as high as 80 for well-graded gravels and gravel-sand mixtures
  - CBR basically identifies soils ability to withstand a load (provide stability to road or airfield)

SOILS

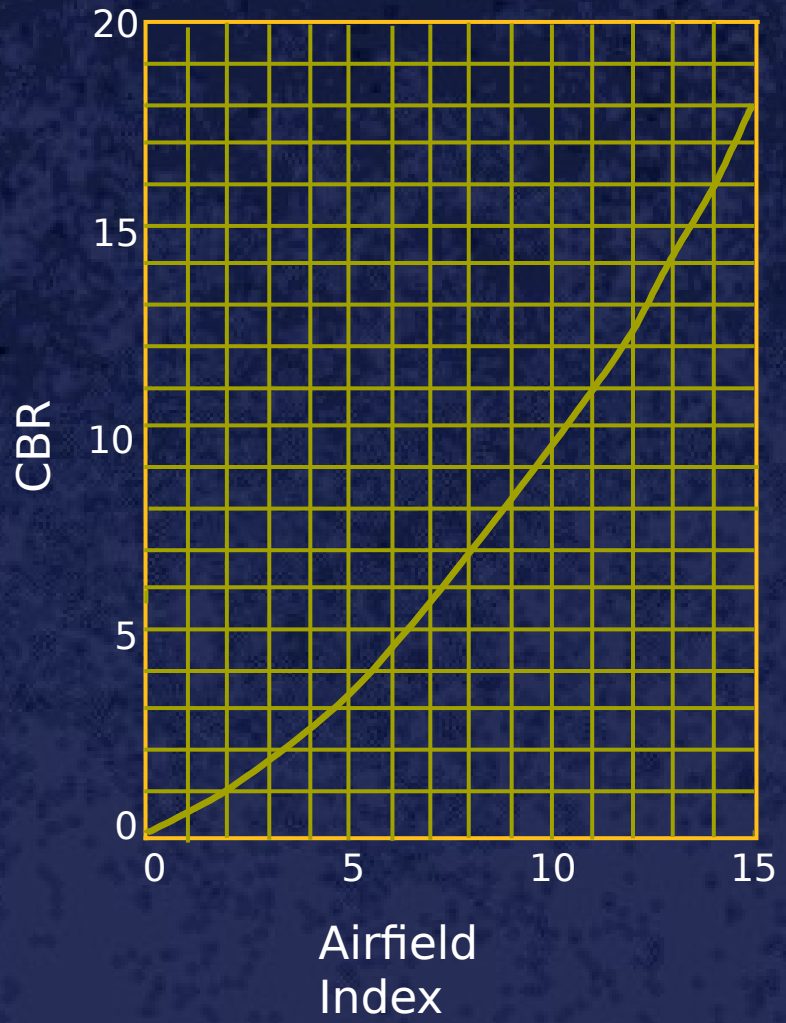
- California Bearing Ratio (cont)
  - Drop Cone Penetrometer or DCP, used to measure CBR
  - EAF Section of MWSS
  - DCP measures soil strength and correlating DCP index with CBR strength values for ops of aircraft or vehicles on unsurfaced soils
  - Can also evaluate aggregate surfaced roads and airfields
  - Appendix C provides CBR values

SOILS

- Airfield Index (AI)
  - Another value to give index of soil strength
  - Found by use of Soil Assessment Cone Penetrometer (SACP)
  - Provides readings from 0 to 15, or AI
  - Correlation between CBR and AI (Fig 2)
  - Works well in silt or clay
  - Gravel too hard
  - Special treatment in sand

SOILS

- Airfield Index (AI)



SUBGRADES AND BASE COURSE

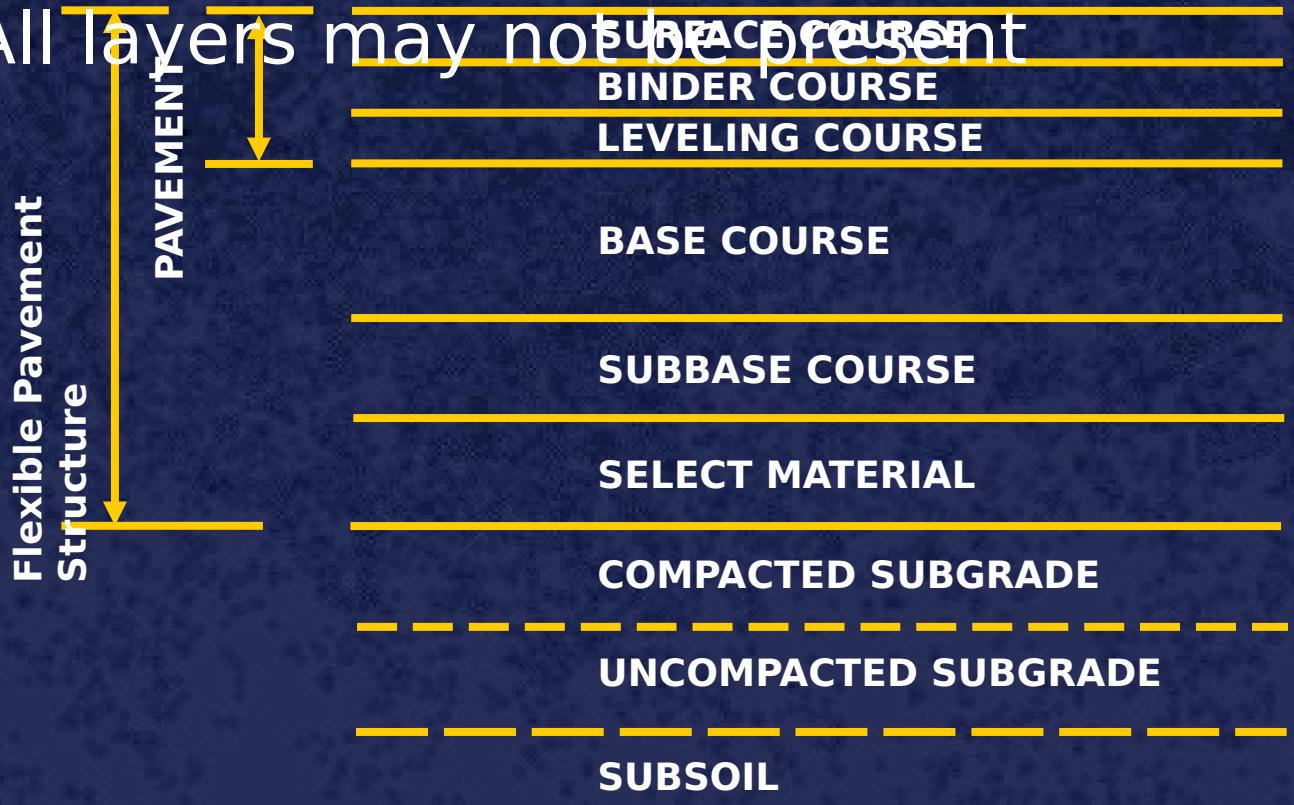
- Design Considerations - pavement structures may be rigid or flexible
  - Rigid pavements - made of Portland cement concrete has great flexural strength
    - Acts as a beam bridging over minor irregularities in base or sub-grade course

SUBGRADES AND BASE COURSE

- Design Considerations (cont.)
  - Flexible Pavement - all other pavements classified as flexible and used almost exclusively for roads and airfields
    - Flexible denotes tendency of all courses in structure to conform to same shape under traffic
    - Any distortion or displacement occurring in sub-grade is reflected in base course and subsequently the surface course

SUBGRADES AND BASE COURSE

- Design Considerations (cont)
  - Typical pavement structure and layers (Fig 3)
    - All layers may not be present



SUBGRADES AND BASE COURSE

- Design Considerations (cont)
  - Flexible pavement design based on principle that magnitude of stress induced by wheel load decreases with depth below surface
  - Stresses induced on given sub-grade mat'l can be decreased by increasing the thickness of the overlying layers (sub-base, base, and surface courses)
- Appendix C provides performances of different soil classifications as sub-grade, sub-base, and base course

SUBGRADES AND BASE COURSE

- Sub-grades
  - Generally that part of soil that acts as foundation for all loads applied above it
  - May consist of existing subsoil and compacted sub-grade
  - Stabilized through compaction, increasing strength

SUBGRADES AND BASE COURSE

- Sub-grades (cont)
  - General factors to determine suitability:
    - General characteristics of sub-grade soils
    - Depth to bedrock
    - Depth to water table
    - Compaction that can be attained
    - CBR values of uncompacted and compacted sub-grades
    - Presence of weak or soft layers or organics in subsoil
    - Susceptibility to frost action or swell

SUBGRADES AND BASE COURSE

- Select Materials/Sub-bases
  - Locally available or other inexpensive mat'l may be used between sub-grade and base course
  - Designated either Select Material or Sub-base
  - Select Material - CBR less than 20
  - Sub-base Course - CBR greater than 20

SUBGRADES AND BASE COURSE

- Select Material/Sub-bases (cont)
  - Select Mat'l normally local, coarse-grained soils (G or S)
  - Sub-base may consist of naturally occurring coarse-grained soils or blended and processed soils
    - May be lime rock, coral, shell, cinders, or disintegrated granite
  - May be stabilized, can be processed and compacted using normal compaction techniques

SUBGRADES AND BASE COURSE

- Base Course
  - Part of the soil profile immediately under wearing surface
  - Purpose is to distribute induced stresses from wheel load so not to exceed underlying soil layers strength
    - Weak sub-grade - thicker base course
    - Strong sub-grade - thinner base course
  - Normally the highest quality structural material used in flexible-pavement structure - high CBR

SUBGRADES AND BASE COURSE

- Base Course (cont)
  - Material should be dense and uniformly graded
  - Meet gradation requirements, plasticity index and liquid limit requirements, as well as compaction
  - Can be stabilized
  - Usually compacted to highest design specs and lift thickness
  - Finish grade determines smoothness of finished flexible pavement
    - Crowned, tight, water-shedding, smooth

SOIL STABILIZATION

- Defined as alteration or preservation of one or more soil properties to improve soil's engineering characteristics and performance
- Used for various reasons:
  - Expedient construction (limited resources)
  - Increase habitability and trafficability

SOIL STABILIZATION

- Three primary functions
  - Strength Improvement - Increase stability of existing soil to enhance load-carrying capability
  - Dust Control - Eliminate or alleviate dust generated by aircraft and vehicles
  - Soil Waterproofing - Preserve the natural or constructed strengths of a soil by preventing ingress of surface water
- Decision to stabilize depends on type material available, drainage, equipment required, prevailing weather

SOIL STABILIZATION

- Factors to consider when choosing specific stabilization technique
  - Airfield Usage
    - Influenced by intended use of airfield
    - Expedient construction(EAF) - short-lived, rapidly constructed
    - Type of aircraft utilizing airfield
    - Classification of airfield

SOIL STABILIZATION

- Factors (cont)
  - Soil Type and Strength
    - Classification and strength of existing sub-grade soils
      - Soil Test / Assessment Kit
      - Other DOD engineers

SOIL STABILIZATION

- Factors (cont)
  - Environmental Conditions
    - Conditions under which the facility must be constructed and perform
    - Include temperature, wind, humidity, precipitation, and groundwater
    - Obtain information from meteorological reports, geologic surveys, intelligence reports, nearby installation data

SOIL STABILIZATION

- Factors (cont)
  - Construction Limitations
    - Military engineers faced with rapid mobilization and accelerated construction schedules
    - Type of equipment available
    - Availability of soil stabilization techniques

SOIL STABILIZATION

- Four Methods
  - Mechanical
  - Chemical
  - Geotextile
  - Subsurface drainage
- May use a combination of each of the four methods

SOIL STABILIZATION

- Mechanical Stabilization
  - Include compaction, blending of soils, and excavation and replacement
  - If soil is of proper gradation, may use HE to grade and compact in order to attain required stability and strength
  - Some cases, unsuitable material removed and replaced with suitable soil

SOIL STABILIZATION

- Chemical (Admixture) Stabilization
  - One of primary methods to add chemical admixture, or stabilizer, to soil
  - Improve stability and strength of sub-grade materials
  - Common types: Lime, cement, bituminous materials, flyash, salt, lignins, or combination
  - Each provides unique advantages and disadvantages, depending on soil type
  - Good for dust and FOD control around airfield, base camp, roads, and FARP sites

SOIL STABILIZATION

- Geotextiles
  - Relatively new method
  - Generic name applied to wide variety of synthetic fabrics used in construction industry
  - Placed on weak sub-grade and covered with coarse aggregate layer
  - Prevents intrusion of aggregate into sub-grade
  - Mobilizes tensile strength enabling geotextile/aggregate to resist deflection

SOIL STABILIZATION

- Subsurface Drainage
  - Constructed where unstable sub-grade conditions exist due to poor drainage
    - Flood plains or low-lying areas
  - Soils may be permeable and sufficiently free-draining such that installation of subsurface drains are effective
  - Once water drained, compact soil to provide necessary sub-grade improvement

SUMMARY

- Soils and Soil Classification, to include gradation, its effects, and the USCS scale
- What the CBR and AI are and importance these criteria have on AF construction
- The two pavement structure and their design considerations
- What Soil Stabilization is, factors to consider, and the four main techniques to accomplish stabilization


QUESTIONS?